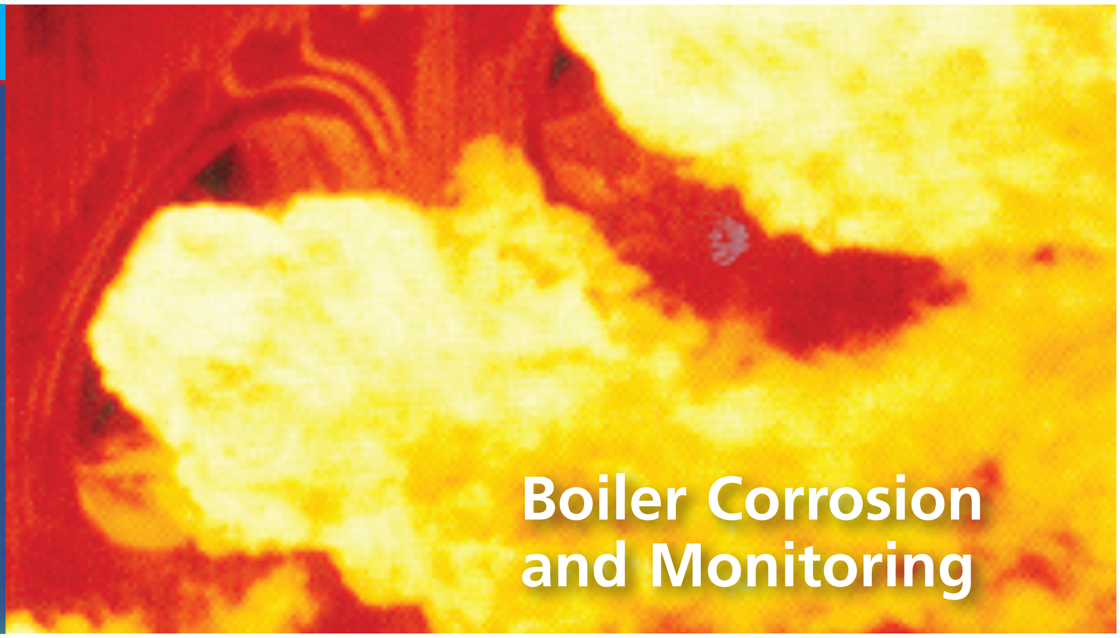
UK-US Collaboration on Fossil Energy R&D

Advanced Materials



Boiler Corrosion and Monitoring

project duration

April 2004 - April 2009

project partners

UK:

*Doosan Babcock Energy Limited

NPL

RWE

University of Cranfield

US:

*National Energy Technology Laboratory (NETL)

Reaction Engineering International

Covanta Energy

InterCorr International

Honeywell Process Solutions

** Task Leaders*

background

Incidence of excessive boiler tube metal wastage due to fireside corrosion has long been a significant issue for coal-fired utility boilers. Boiler design rules and features introduced in the 1950's and 1960's in response to corrosion problems at that time have proven reasonably successful with the occurrence of excessive corrosion being relatively rare.

However a number of developments are changing this position:

1. Primary NOx emission control technologies, which implement harsh furnace conditions
2. Co-firing non-conventional fuels (e.g. biomass) in coal-fired boilers, which affect ash deposits
3. Advanced coal-fired boiler operating conditions producing higher steam pressures and temperatures
4. Oxyfuel firing technology producing very high flue gas acidic species concentrations such as SO_2 / SO_3 and HCl

An ability to control fireside corrosion to acceptable levels is imperative for the successful development of advanced coal-fired boilers. This programme of work was developed to gain a better understanding of these key issues by bringing together UK & US organizations with specific expertise and interest in boiler corrosion.

objectives

- To review plant experience of furnace wall, superheater and reheater corrosion
- To develop and apply optimized in-situ monitoring and analysis techniques for applications that include biomass co-firing, oxyfuel firing and waste incineration
- To evaluate candidate alloys under accurately controlled conditions reflecting current and advanced boiler operations
- To further develop laboratory characterization of boiler corrosion processes relevant to advanced power plant and to model the extent and mechanisms of degradation involved and to develop a predictive capability relevant to real plant performance

work program

The work program was focussed on two main topics:

- The development and performance of laboratory-scale, high temperature corrosion experiments
- The development, implementation and assessment of corrosion probe techniques for the measurement of corrosion rates in utility boilers

Doosan Babcock Energy Ltd., Cranfield University, NPL and NETL were involved in laboratory experiments to assess the corrosion resistance of selected materials and provide important corrosion rate and mechanism information. Testing included exposures in simulated flue gases with deposits typical of those from boilers using world-sourced coals, with conventional and oxyfuel firing as well as biomass co-firing. The effects of heat flux and alternating atmosphere were also investigated.

work program

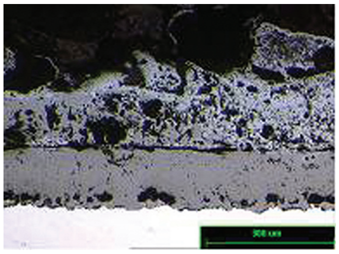


Figure 1.
T92 coupon exposed during a laboratory experiment

Figure 1 shows typical corrosion morphology for the 9% Cr alloy, T92 examined in the programme.

There were a number of approaches to corrosion probe design, from one based on the measurement of material loss of a sacrificial test specimen to various types of electrochemical devices.

Doosan Babcock Energy was involved with the further development of a simple furnace wall corrosion probe system. During an exposure campaign, probe tip temperatures are continuously monitored and periodic gas sampling is completed to assess the nature of the local environment. Probes were exposed in a 600 MWe, UK coal-fired utility boiler during two campaigns of 6,700 and 9,200 hour duration. This boiler had been converted to operate with a Boosted Over-Fire Air (BOFA) system, which requires a portion of the furnace to operate under reducing conditions.

NETL, Honeywell Process Solutions and Covanta Energy developed and tested an electrochemical corrosion probe system for application in waterwall and convective region locations. Prototypes were tested at a Waste to Energy (WTE) power plant site.

A comprehensive system involving the application of electrochemical sensor devices for monitoring waterwall corrosion in coal-fired utility boilers was developed by REI. American Electric Power assisted in this activity, providing access, resources and performance data at commercial utility sites.

Cranfield University was involved with the development of a continuous corrosion monitoring system based on electrochemical noise measurement (ECN) and heat flux. A photograph of a probe, post exposure is presented in Figure 2.

key results

General

- A review of plant experience in the field of furnace wall and superheater/reheater corrosion was conducted

Laboratory Studies:

- Corrosion test results allowed for ranking of test materials in a variety of atmospheres. The performance of candidate new materials in-service can tentatively be predicted by comparing them with materials for which in-service performance information is known
- Some potential effects of oxyfuel firing on corrosion rate were identified
- Alternating atmosphere test results indicated that changing conditions impacts on scale growth in furnace corrosion. These findings suggest that alternating conditions may be a consideration for future laboratory test work

Corrosion Probe Studies:

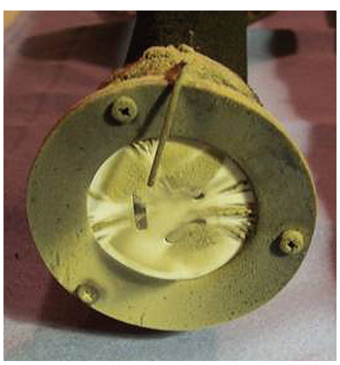


Figure 2.
Deposit covered electrochemical noise probe sensor following exposure test

- Comparison of corrosion rates for a furnace operating with a BOFA regime with those of the same unit pre-BOFA showed that there was no significant increase in rates at the test locations, despite harsher gas conditions
- Electrochemical noise probes were shown to be sensitive to compositional differences between alloys and environmental variances. Data from standard electrochemical techniques allowed the production of electrochemical polarization diagrams that are typical of those for actively corroding metals
- Electrochemical corrosion probe activities indicated that they can currently only be used in a semi-quantitative manner
- Electrochemical corrosion rates measure less of the corrosion reaction than measured by either dimensional or mass loss measurements.
- Field testing of prototype probes provided indicators for future design improvements in their robustness and reliability

future activities

- Develop laboratory procedures incorporating realistic conditions such as fluctuating atmospheres and temperature cycling in order to provide better links between laboratory experimentation and in-service plant operation
- Develop an improved understanding of the relationship between fuel diet and boiler operating conditions with the rate of corrosion recorded by electrochemical corrosion probes
- Use field test data to improve the reliability of probes for commercial application

Further information on the UK-US Collaboration on Energy Research and Development, please visit - http://us-uk.fossil.energy.gov/